WATT PILOT

Motorized Attenuator

USER MANUAL

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1. Introduction

This manual is designed to help to install and operate Watt Pilot. This manual is a part of the product. Please read instructions of installation and operation carefully, before installing and operating Watt Pilot. Safety instruction must be read especially careful. If there is any questions about contents of this manual please contact Altechna. Altechna reserves the right to update contents of the manual without notification.

1.1. Watt Pilot short description

Motorized Watt Pilot is a computer controlled laser beam attenuation device. It attenuates free space laser beam/pulse continuously without introducing additional energy fluctuations. Watt Pilot is essential in systems, where stable laser power adjusting is necessary. User friendly software “ALT-Step” or “SCA” are recommended to control Watt Pilot via PC.

1.2. General safety requirements

Motorized Watt Pilot is designed to operate in conjunction with laser system. All applicable rules and regulations for safe operation of lasers must be known and applied while installing and operating Watt Pilot. The customer is solely responsible for laser safety while using Watt Pilot as standalone or integrated into system. The customer must use suitable protective measures.
While assembling or operating Watt Pilot, cannot be stared into direct or scattered laser beam. All parts of the body must be kept away from the laser radiation. While adjusting laser beam path through Watt Pilot laser power must be low as possible. The risk of hazardous laser radiation can increase while optical components or instruments are used in combination with Watt Pilot. Appropriate eye protection must be worn at all times.
Electrical safety requirements must be complied while assembling and operating Watt Pilot.

1.3. Operating and storage conditions

Environmental conditions that must be hold while storing, servicing and operating are:
Storage temperature should be between -35 ℃ and +60℃. Operating temperature is 25 ℃ ± 10 ℃. Watt Pilot must be protected from humidity, dust and corrosive vapors to avoid damaging optical components and electronics. Avoid strong static electricity and electromagnetic fields.

2. Operation principle

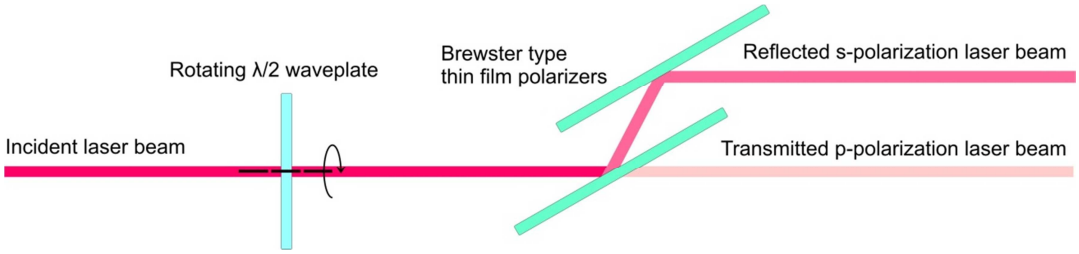


Figure 1. Watt Pilot principle of operation. Color differences shows intensity of laser beam. Brighter red means more intensive laser beam.

The Motorized Watt Pilot incorporates 2 high-performance brewster type thin film polarizers, which reflect s-polarized light while transmitting p-polarized light. Rotating phase retardation of λ/2 waveplate is placed in the incident polarized laser beam. The intensity ratio of those two beams may be continuously varied without alteration of other beam parameters by rotating the waveplate. The intensity of either exit beam, or their intensity ratio, can be controlled over a wide dynamic range. P-polarization could be selected for maximum transmission, or high-purity s-polarization could be reflected when maximum attenuation of the transmitted beam takes place. Proper functioning of Watt Pilot requires optimal configuration of optical elements regarding to incident laser beam. Watt Pilot output polarization contrast depends on incident laser beam polarization contrast. Higher incident laser beam polarization contrast, leads to higher Watt Pilot output polarization contrast.

2.1. Watt Pilot main components

Optical components are placed into mechanical holders. Main mechanical components of motorized Watt Pilot are shown in figure 2. Waveplate mount is designed to 1 inch diameter waveplate λ/2.

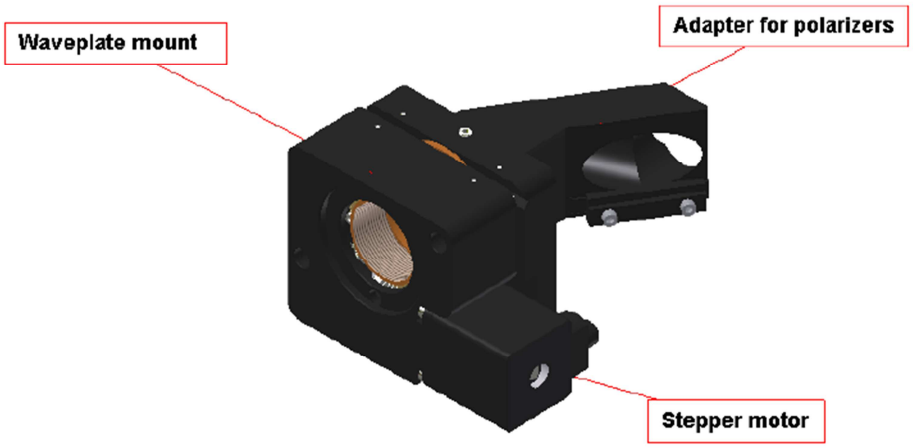


Figure 2. Main components of Watt Pilot.

Wave plate mount is attached to micro step motor. Waveplate inside the waveplate holder is rotating around the optical axis of incident laser beam. Micro step motor and waveplate mount are shipped together in one piece, if there is no other request. Brewster type thin film polarizers are placed into adapter for polarizers. Polarizers to the mount are fixed using 4 plastic bolts. Adapter for polarizers and waveplate mount are fixed while using M4 screw with vinyl cap. Watt Pilot might be fixed to an optical table using posts and clamps or to the custom system while using M6 screw on the bottom.

3. Assembling

Figure 3. Assembling the Watt Pilot.

Watt Pilot assembling steps:

Step 1 Place polarizers into mechanical adapter. Polarizers must face each other with surfaces coated with polarizing coating. Polarizing coating is marked with an arrow, so you have to put the polarizers with the arrows on the sides facing each other. Then fix polarizers with the plastic bolts (use all 4 plastic bolts to fix one polarizer).
NOTICE: do not tighten up the bolts too much since it can bend the

polarizer and thus distort the laser beam.

Step 2 Put wave plate into attenuator between two mounting rings as shown. Be sure the wave plate is immobilized tightly.

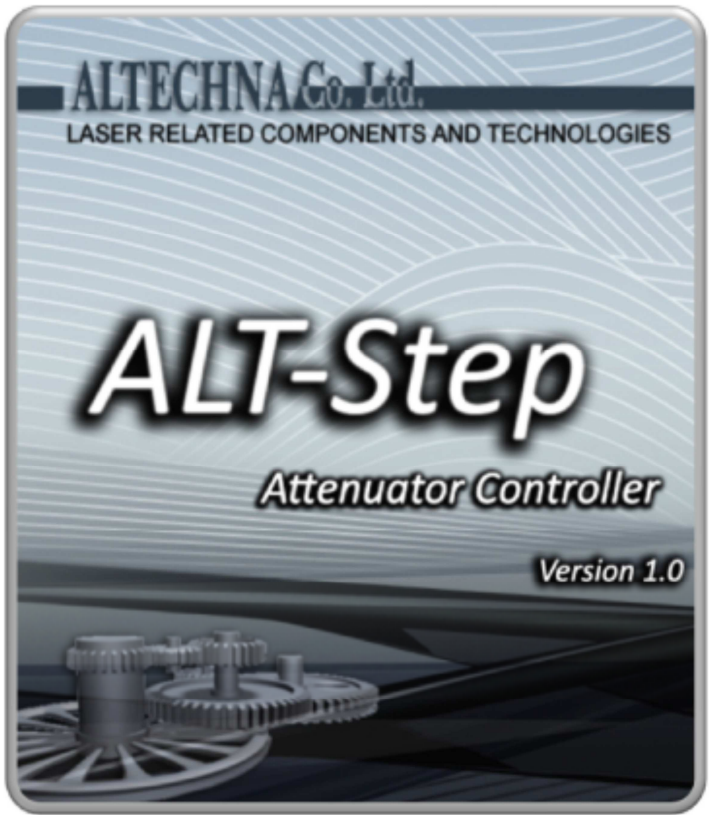
Step 3 Attenuator consists of two mechanical parts. You should assemble both mechanical parts together.

Step 4 Use fixing screw for tightening both parts together.

PEASE NOTICE: Powder free gloves must be worn while mounting optical components. Avoid touching and scratching optical surfaces.

4. Watt Pilot control software

USB version controller of Watt Pilot can be controlled via computer using “ALT-Step” software Watt Pilot control software is the automated laser power attenuator solution.



Main features:

I. Simple stand-alone controller.
II. User – friendly software interface.
III. High precision.
IV. Simple text – based communication protocol.
V. Easy to integrate.

4.1. Software installation

Launch WattPilotSetup.exe (from USB stick) program to install control program. Please notice that if you don't have Windows Framework installed, you will be prompted to do that. Windows Framework can be downloaded from Microsoft web page automatically or, alternatively, it can be found a copy in USB stick (file dotnetfix.exe).

4.2. First steps

Main window of Watt Pilot software is called “Attenuator” and shown in figure 5. In this window there are controls to set energy, open *Configuration* and *Direct Control* dialogs. Using *Direct Control* dialog user can directly enter position in steps for the stepper motor as shown in figure 6.

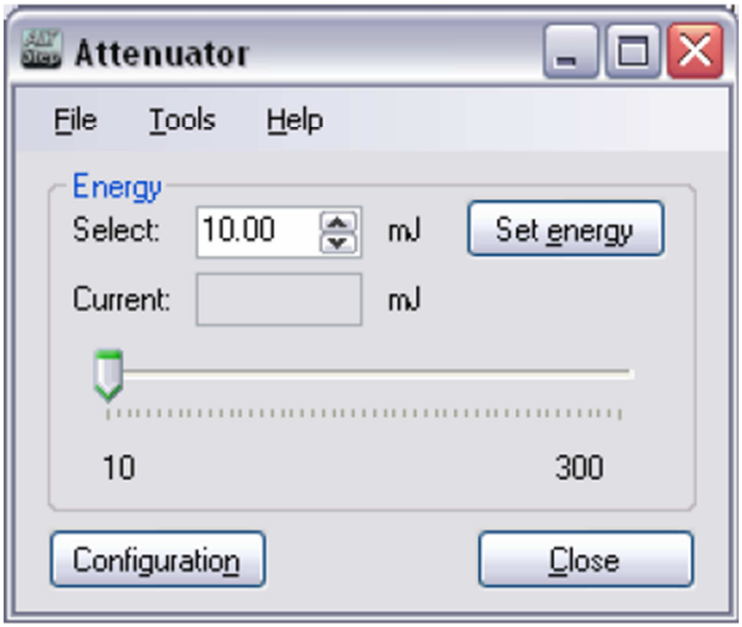


Figure 5. Main window of “WattPilot”.

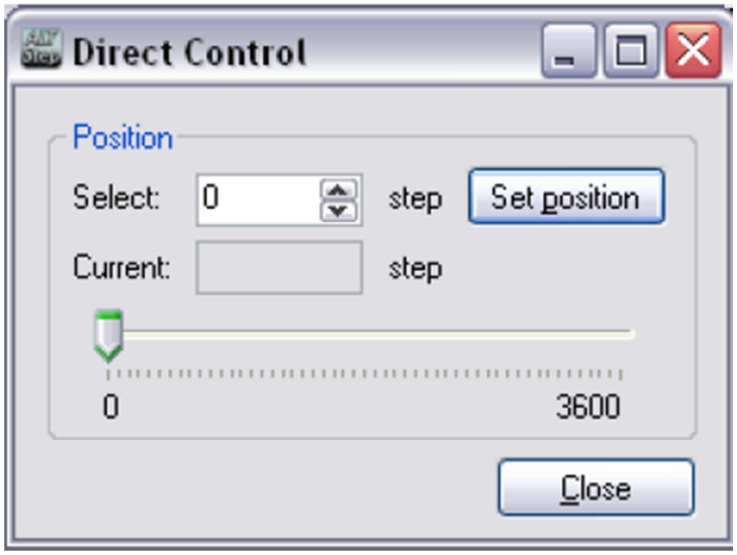


Figure 6. Direct control dialog.

Energy that can be changed in main window (figure 5) can be determined using equation (1):

$$E = E_{min} + (E_{max} - E_{min}) * [\cos(k * x)]^2 \quad (1)$$

E_{min} is the minimal energy, E_{max} is the maximal energy, k is the steps per degree ratio, and x is current position in steps. Calibration procedure is described in chapter “IV.I. Configuration”.

4.3. Configuration

Configuration dialog (figure 7) allows calibrating attenuator and changing some basic program parameters.

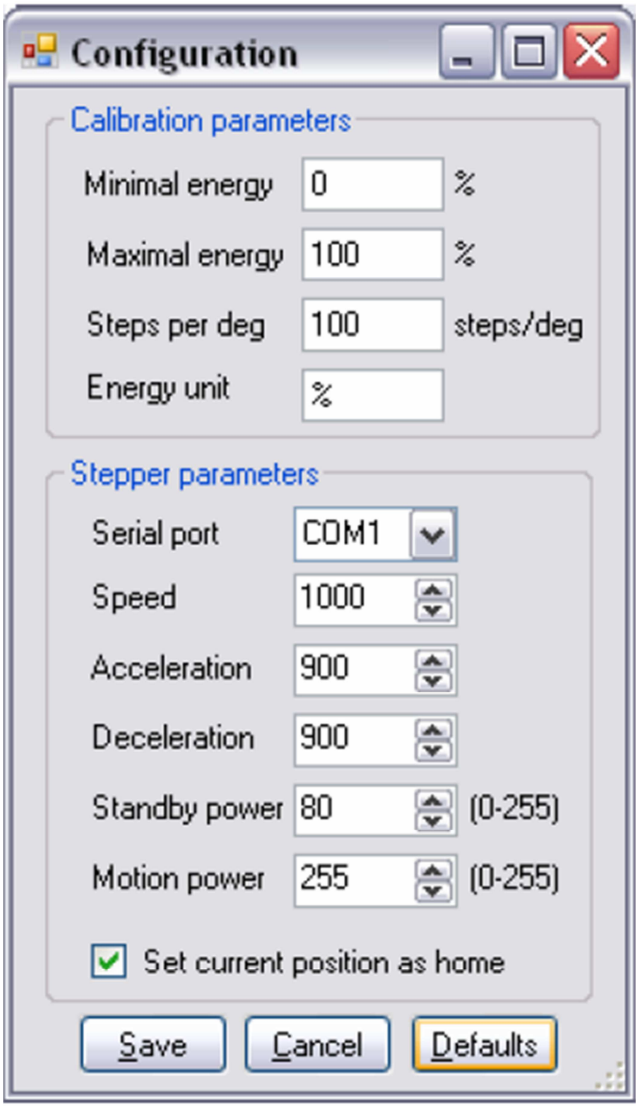


Figure 7. Configuration dialog.

Minimal energy E_{min} and maximal energy E_{max} values should be measured directly. Coefficient k is number of stepper motor steps degree and is provided together with attenuator specification. Position in steps should be zero when $E=E_{max}$. Use “Set current position as home” to reset current position value.

Calibration and stepper parameters:
Energy unit – short name of the energy units used.
Serial port – serial port of the PC that is connected to the controller of "Watt Pilot".
Acceleration – acceleration of stepper motor when motion is started.
Deceleration – deceleration of stepper motor when motion is finishing.
Standby power – Power applied to the motor when it is not moving. It is necessary to decrease the applied power level in order to avoid stepper motor overheating.
Motion power – power applied to the motor while moving.

4.4. Keyboard shortcuts

For quick manual position tuning several keyboard keys were mapped to the following characters:

Increase position single step: **u**
Decrease position single step: **j**

Increase position 10 steps: **i**
Decrease position 10 steps: **k**

Increase position 100 steps: **o**
Decrease position 100 steps: **l**

4.5. Controlling "Watt Pilot" using "HyperTerminal"

For "Windows Vista" and "Windows 7" "HyperTerminal" emulator could be used. For example: "Indigo Terminal Emulator". First of all COM port used by Watt Pilot soft must be known. Procedure described below and shown in picture 8.

Right click My Computer (1) → Properties (2) → Device Manager (3) → Ports (COM & LPT) (4). Find a port called USB Serial Port in the list (Watt Pilot controller box must be connected to PC). Remember the number of this port (e.g. COM9). Number of this port is needed also while working with "WattPilot"

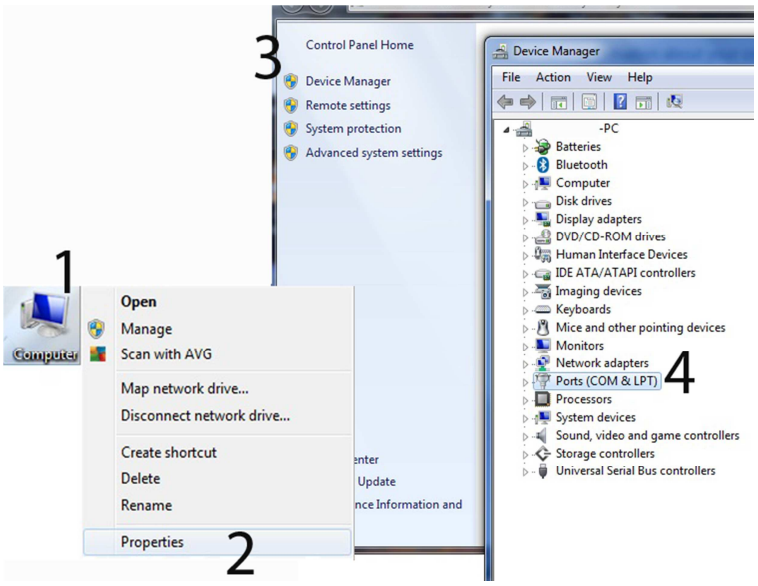


Figure 8 Finding out which USB port is used by Watt Pilot**.**

If “Windows XP” is used “HyperTerminal” can be found:
Start -> All Programs -> Accessories -> Communications -> HyperTerminal.
If “HyperTerminal” emulator is used, please launch from location where it is installed.
When clicked on “HyperTerminal”, window shown in figure 9 appears.

Figure 9. “HyperTerminal” connection window.

In window shown in *figure 9* please write in random name and click “OK”.

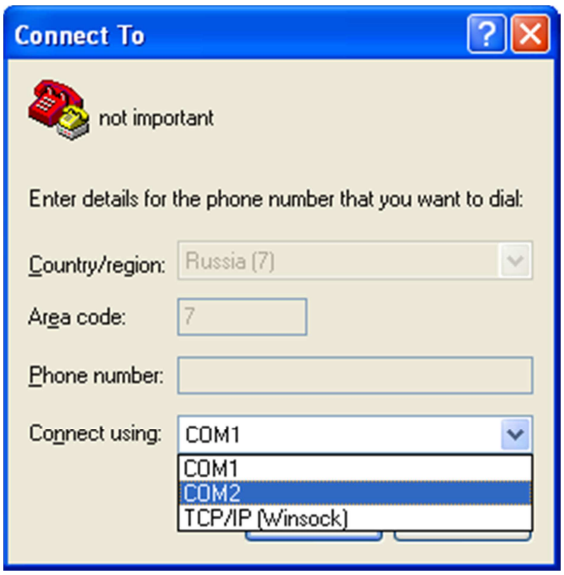


Figure 10. Choose COM port used by “Watt Pilot”.

In window shown in *figure 10* please choose COM port used by “Watt Pilot”.

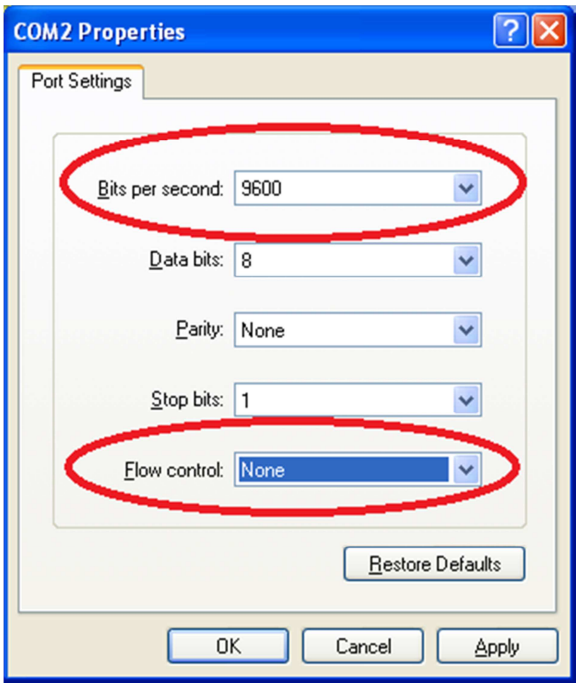


Figure 11. COM port properties window.

In COM port dialog window please choose “Bits per second” = 9600 and “flow control” = None and click “OK”.

Window shown in *figure 12* appears. Press connect button (red circle) if needed. Type commands to "hyper terminal" window. Commands are listed in chapter “IV.IV. Command set”.

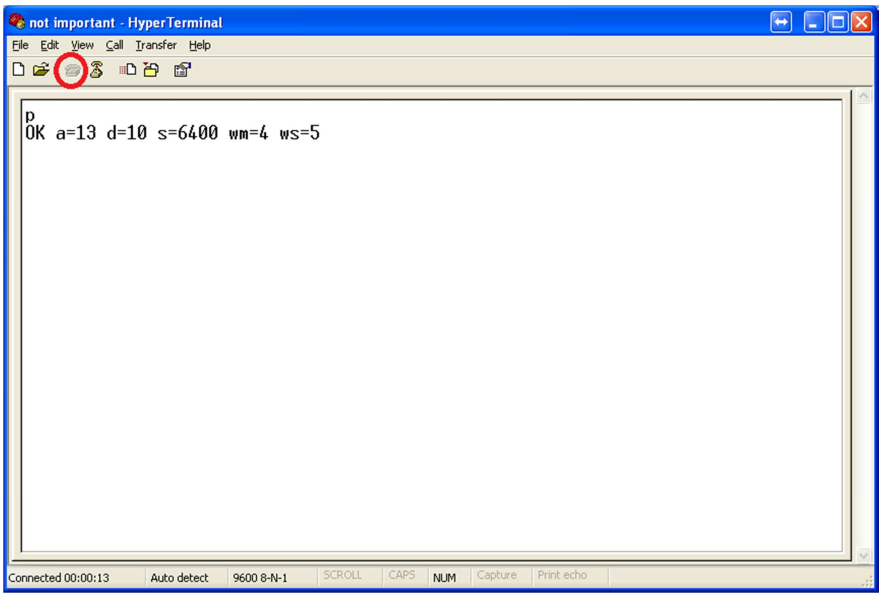


Figure 12. HyperTerminal control window.

4.6. Command set

Notation: <n> - integer number (0-255), <a> - axis name: X, Y, or Z. Text in Bold font means the string sent to or received from controller. Communication protocol is text – based and is case – sensitive. Command is delimited by new – line symbol **\n\r**. One command line is follower by one response line. No data should be sent until response to the command is received. Response line starts with **OK** if command was executed successfully otherwise **ERR** followed by an error message is sent. Commands are described in table

Table 1. Command list.

Command	*Responce*	*Description*
p	**OK a=<n> d=<n> s=<n> wn=<n> ws =<n>**	Show current parameter values. a – acceleration, d – deceleration, s – speed, wm – motion mode power, ws – standby mode power.
a<n>	**OK**	Set acceleration parameter and store new value in permanent memory.
d<n>	**OK**	Set deceleration parameter and store new value in permanent memory.
s<n>	**OK**	Set speed parameter and store new value in permanent memory.
wm<n>	**OK**	Set motor power value <n> (1-255) for motion mode and store new value in permanent memory.
ws<n>	**OK**	Set motor power value <n> (1-255) for standby mode and store new value in permanent memory.

o	**OK X=<n> Y=<n> Z=<n>**	Show current X, Y, Z coordinates.
h<a>	**OK**	Set current position for axis <a> as home position.
m<a><n>	**OK X=<n> Y=<n> Z=<n>**	Move <a> axis <n> steps relatively to the current position. Response includes coordinates after motion was finished.
g<a><n>	**OK X=<n> Y=<n> Z=<n>**	Move <a> axis to the absolute position <n>. Response includes coordinates after motion was finished.

5. “Watt Pilot” controller features (TTL controller)

Figure 8. Watt Pilot controller (TTL controller version)**.**

Features:

- Half stepping.
- Galvanic isolated inputs.
- 3.3 V and 5 V tolerant inputs.
- Input clock/step frequency up to 2000 Hz

5.1. Input signal requirements for TTL version controller.

Controller inputs are optocoupled, it means there are no galvanic connection between power supply and signal source. This eliminates any motor generated electrical noise and allows simple controller installation. However this requires slightly more current from source, but majority of microcontrollers/fpga are able to drive LED of optocouple directly. Input circuit is shown in the figure below. To reduce 5 V logic current, resistors of 180 Ohm can be added in series with STEP and DIR lines. 4 and 5 pins are connected to mechanical zero position switch directly. Some debouncing circuit may be considered if zero switch is used, for example a capacitor in parallel with switch. *Switch is closed if in zero positions.*

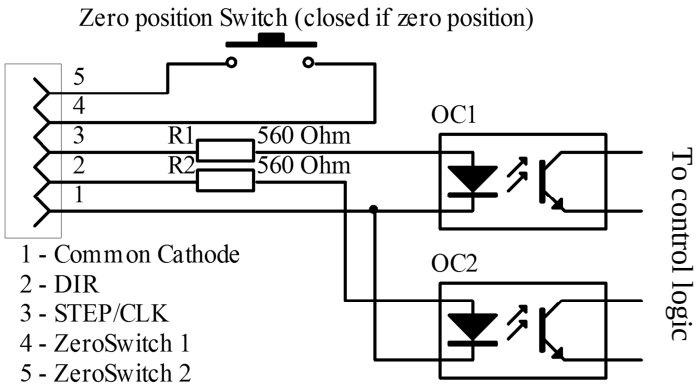


Figure 9. Circuit diagram of input section

Table 2. Input signal electrical characteristics.

Parameter	MIN	TYPICAL	MAX	UNITS
Input voltage, high level	2.8		5.5	V
Input voltage, low level			2.3	V
Input current: @ 2.8 V		4.6		
@ 3.3 V		5.2		mA
@ 5 V		6.8		

5.2. Input signal timing for TTL version controller

Motor turns one step after rising edge of STEP signal. Proper DIR voltage must be applied before rising edge (time t_{DIR1}). Rise/Fall times of signals do not matter if there are used timings, shown in the diagram below. Grayed parts in

DIR timeline show moments then DIR level do not matter, can be changed and white slots show when DIR level must be kept stabilized.

It is necessary to mention that motor shaft is inert. Frequency of STEP signal must be controlled linearly, especially at high motor speeds. Motor should accelerate and decelerate smoothly. For instance, control logic must sweep down STEP frequency before changing DIR level. Similarly, frequency must be swept up then reaching high motor speed.

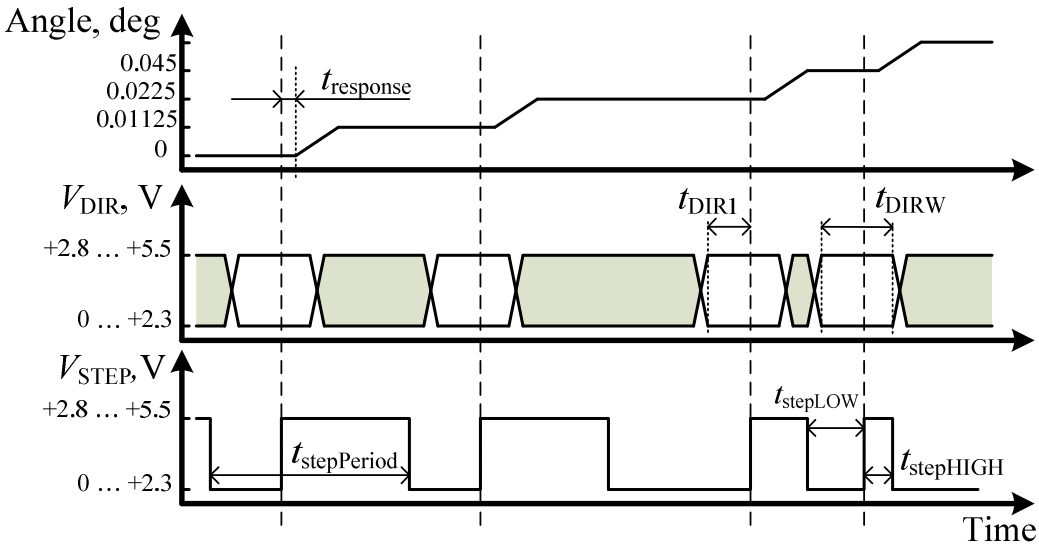


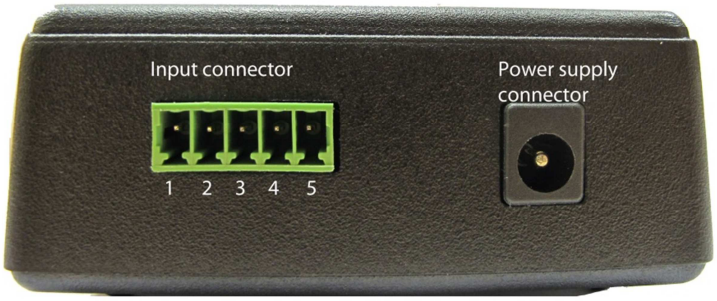
Figure 10. Input signal timing. It is considered that DIR signal is always kept high in this example and angle is increasing on every STEP rising edge.

Table 3. Input signal timing (parameters may vary depending on Watt Pilot version).

SYMBOL	DESCRIPTION	MIN	MAX	UNITS
$t_{stepLOW}$	STEP low level duration (0 V)	30	-	µs
$t_{stepHIGH}$	STEP high level duration (2.8 V – 5 V)	400	-	ns
$t_{stepPeriod}$	STEP period (determined by motor)	0.5	-	ms
t_{DIR1}	Time to prepare DIR level before STEP rising edge	30	-	µs
t_{DIRW}	DIR pulse width	30.4	-	µs
$r_{response}$	Delay between STEP rising edge and current applied to motor windings	-	30	µs

5.3. Watt Pilot electrical connections for TTL controller version.

Figure 11 and figure 12 shows locations of electrical connection. Watt Pilot is controlled by a 9 pin D-SUB female connector.



Input connector pins:
1. Common Cathode
2. DIR
3. TEMP
4. Zero position switch
5. Zero position switch
Power supply connector pins:
1. Internal pin “+”.
2. External pin “-“.

Figure 11. Input and power supply connectors.

Figure 12. Motor connector and pin out.

6. Watt Pilot electrical/mechanical characteristics

Watt Pilot electrical and mechanical characteristics are shown in table 3.

Table 4. Electrical/mechanical characteristics.

PARAMETER	VALUE	UNITS
λ/2 Waveplates Holder Angular Resolution	0.01125	deg/step
Steps Per full Turn	32000	steps
Controller Step Response time, $r_{esponse}$*	30	μs
Maximum Frequency of STEP Signal**	2000	Hz
Maximum Controller Power supply Voltage	10	V

* Delay between STEP signal rising edge and current applied to motor windings, see table 3.
** Step frequency can be increased by using more powerful power supply. Considering our motor performance, noise and heat dissipation, 5 V / 1.2 A power supply is optimal
Parameters may vary depending on which controller is used.

7. Mechanical dimensions.

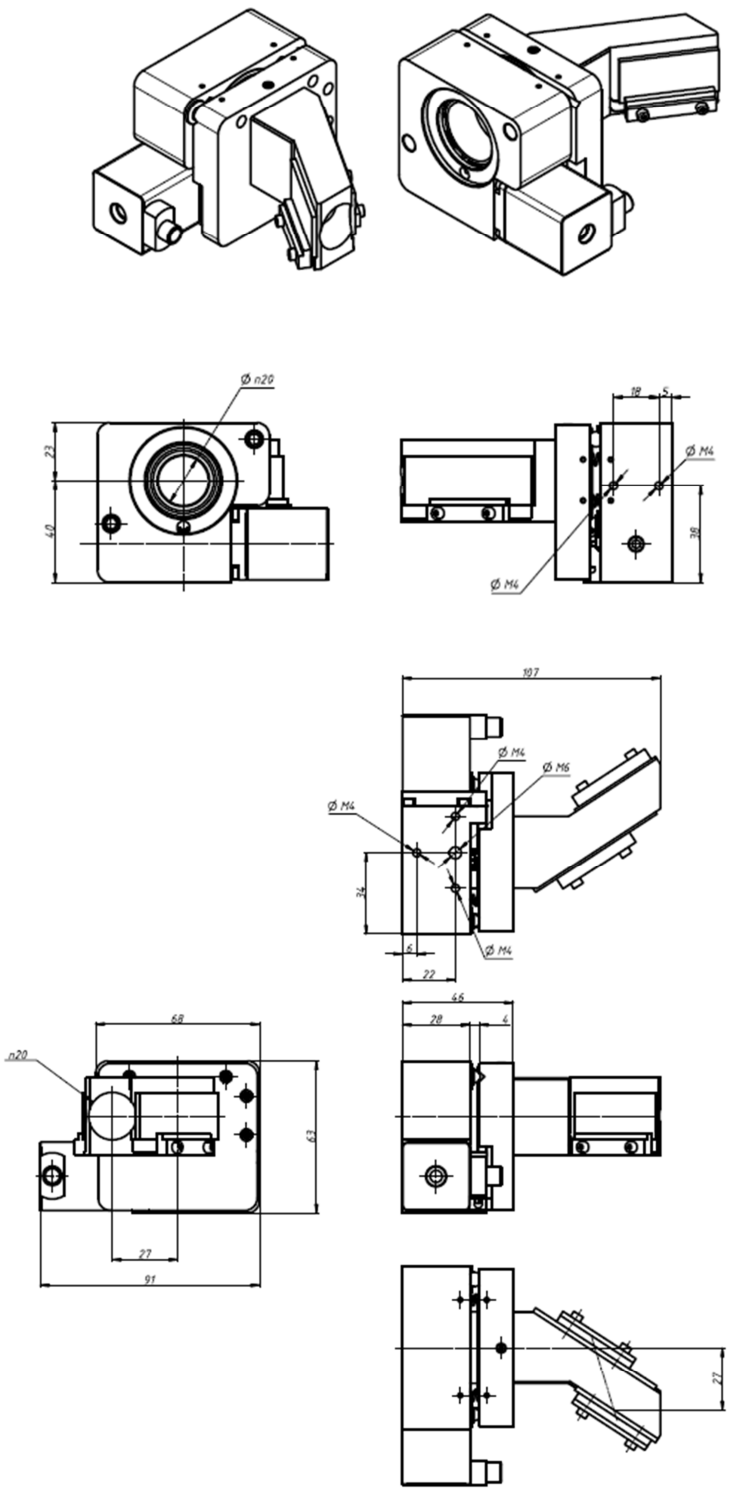


Figure 13. Mechanical dimensions of Watt Pilot.